

## Patent Claims

1. A method for monitoring the adjustment movement of a component, in particular a window pane or a sunroof  
5 in motor vehicles, which is driven by a drive device and can be adjusted in a translatory or rotary fashion, characterized in that a plurality of input signals which can be derived from the drive device (2, 3) and which represent a deceleration of the adjustment  
10 movement of the drive device (2, 3) are input at input neurons (10; 101, 102, 103) of an input layer (61) of a neural network (6) with at least one hidden layer (62, 63) having hidden neurons (11; 111, 112), said network (6) outputting, at at least one output neuron (12) of  
15 an output layer (64), an output value which corresponds to the adjusting force or to a trapped state or nontrapped state.

2. The method as claimed in claim 1, characterized in  
20 that the input signals which can be derived from the drive device (2, 3) indirectly represent deceleration of the adjustment movement of the drive device (2, 3).

3. The method as claimed in claim 1 or 2,  
25 characterized in that deceleration of the adjustment movement of the drive device (2, 3) is determined by changing the period length and/or the motor current and/or the motor voltage of a drive motor (3) of the drive device (2, 3).

30 4. The method as claimed in at least one of the preceding claims, characterized in that the input signals which can be derived from the drive device (2, 3) are output in parallel or in series to the input  
35 neurons (10; 101, 102, 103) of the input layer (61) of the neural network (6).

5. The method as claimed in at least one of the preceding claims, characterized in that the inputs of the input layer (61), of the hidden layer (62, 63) and of the output layer (64) as well as the connections (14) of the input layer (91) to the at least one hidden layer (62), the connections (15) of the plurality of hidden layers (62, 63) to one another and the connections (16) of a hidden layer (63) to the output layer (64) have differing weightings.

10 6. The method as claimed in at least one of the preceding claims, characterized in that the hidden neurons (11; 111, 112) of the at least one hidden layer (62, 63) and the at least one output neuron (12) of the output layer (64) have a constant threshold value or bias which shifts the output of the transfer functions of the neurons (10, 11, 12; 101, 102, 103; 111, 112) into a constant region.

7. The method as claimed in at least one of the preceding claims, characterized in that at the input neurons (10; 101, 102, 103), hidden neurons (11; 111, 112) and/or output neurons (12) of the neural network (6), in a learning phase,

- random weightings are assigned,
- various input patterns which are applied to the input neurons (10; 101, 102, 103) are predefined, and the associated at least one output value is calculated, and
- the weightings and/or the threshold value are changed as a function of the difference between the at least one output value and at least one setpoint output value.

8. The method as claimed in claim 7, characterized in that the degree of change in the weightings depends on the size of the difference between the at least one output value and the at least one setpoint output value.

9. The method as claimed in claim 7 or 8, characterized in that the output value is measured with a clip-on force measuring instrument at different spring constants or in particular at 2 N/mm and 20 N/mm, and in that the clip-on  
5 force measuring instrument outputs the measured output value in a way which is analogous to the input values.

10. The method as claimed in at least one of the preceding claims, characterized in that the motor period, the motor  
10 current and/or the motor voltage of the drive motor (3) are input into the input neurons (10; 101, 102, 103) as input signals.

11. The method as claimed in one of the preceding claims,  
15 characterized in that an adaptation period which specifies the period calculated at a predefined reference voltage and which is associated with the position of a reference distance stored in the learning phase is input into the input neurons (10; 101, 102, 103) as an additional input signal.

20 12. The method as claimed in claim 11, characterized in that the adaptation period is averaged in that the neural network calculates a new adaptation period at each full rotation of the drive motor or in four quarter periods of the drive  
25 motor, said new adaptation period being made available at the next adjustment movement as an adaptation period.

13. The method as claimed in at least one of the preceding claims, characterized in that the input values of the input  
30 neurons (10; 101, 102, 103) are composed of

- the values of an adaptation profile of the component which can be adjusted in a translatory fashion,
- the values of an adaptation period when the component which can be adjusted in a translatory fashion is  
35 adjusted,
- a run up flag,
- the output values of a shift register for terminal voltages of the drive motor,
- the output values of a shift register for period values,

- the temperature of the drive motor,
  - the ambient temperature,
  - a speed signal
  - an oscillation voltage, and
  - 5 - a preceding output value,
- and the force which is determined by neural means is output as an output value of an output neuron.

14. The method as claimed in at least one of the  
10 preceding claims, characterized in that, in the learning phase of the neural network (6), input patterns which are applied to the input neurons (10; 101, 102, 103) and the force values which are output by the at least one output neuron (12) are selected and/or  
15 predefined as a function of the desired sensitivity of the system at low spring constants.

15. The method as claimed in claim 14, characterized in that the learning component in the learning phase of  
20 the neural network (6) is composed of the adaptation period which is determined anew in the application after each pass.

16. The method as claimed in claim 14 or 15,  
25 characterized in that the learning phase takes place in a vehicle before the operational application.

17. The method as claimed in claim 16, characterized in that the weightings of the neural network (6) which  
30 are determined in the learning phase are defined during the operational application.

18. The method as claimed in at least one of the preceding claims, characterized by an adaptation device  
35 (9) for determining signals of the drive device (2, 3) which are standardized to a reference value, and for outputting adaptation values to the input layer (61) of the neural network (6).

19. The method as claimed in claim 18, characterized in that the adaptation device (9) outputs the adaptation values to the input neurons (10) of the neural network (6) as an additional input signal as a  
5 function of the position.

20. The method as claimed in claim 18 or 19, characterized in that the adaptation device is composed of a neural adaptation network (9) to whose input  
10 neurons (30, 31) at least one signal of the drive device (2, 3) is applied and whose at least one output neuron (35) outputs the position-dependent adaptation values to the neural network (6).

21. The method as claimed in claim 20, characterized in that additional parameters such as the ambient temperature, climatic data or the temperature and the cooling behavior of the drive motor (3) of the drive device (2, 3) are applied to the input neurons (30, 31)  
20 of the neural adaptation network (9).

22. The method as claimed in claim 11 or 12, characterized in that the adaptation device has a model of the drive device, a fuzzy system or a mathematical  
25 model with a genetically generated algorithm.

23. The method as claimed in at least one of the preceding claims, characterized in that the drive motor (3) is stopped or reversed as a function of the output  
30 value of the neural network (6) and the spring constant.

24. The method as claimed in claim 23, characterized in that the logic combination of the spring constant of the drive device (2, 3) with the output value of the  
35 neural network (6) is carried out by means of a logic circuit, a mathematical model with an algorithm or a neural logic network.

25. The method as claimed in claim 23 or 24, characterized in that the rotation speed of the drive motor (3) is sensed, and the difference in rotational speed between two periods is formed and logically combined with the output value of the neural network (6) in such a way that

- when a first switch-off threshold value ( $ASW_1$ ) of the output value of the neural network (6) and a difference in rotational speed which is smaller than a predefined threshold value (SF) for the difference in rotational speed is exceeded, the drive motor (3) is stopped or reversed up to the end of the adjustment movement only if the output value of the neural network (6) exceeds a second switch-off threshold value ( $ASW_2$ ) which is greater than the first switch-off threshold value ( $ASW_1$ ),
- when a first switch-off threshold value ( $ASW_1$ ) of the output value of the neural network and a difference in rotational speed which is greater than a predefined threshold value (SF) for the difference in rotational speed are exceeded, the drive motor (3) is stopped or reversed,
- when the second switch-off threshold value ( $ASW_2$ ) is exceeded the drive motor (3) is stopped or reversed irrespective of the difference in rotational speed.

26. The method as claimed in claim 25, characterized in that when the first switch-off threshold value ( $ASW_1$ ) of the output value of the neural network (6) and a difference in rotational speed which is smaller than the predefined threshold value (SF) for the difference in rotational speed are exceeded, stopping or reversing of the drive motor (3) are blocked even if the difference in rotational speed ensuring the further adjustment movement of the drive device (2, 3) is greater than the predefined threshold value (SF) for the difference in rotational speed.

27. The method as per at least one of the preceding features having the following steps:

- evaluation of the input signals by means of the neural network in order to determine a state of the motor vehicle and/or a state of the adjustment device;

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- selection of a set of weightings for the neural network from a multiplicity of sets of weightings irrespective of the evaluation of the input signals and the determined state, and
  - use of the selected set of weightings to operate the neural network while the drive device of the adjustable component is being controlled.